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CENTER FOR REMOTE SENSING AND CARTOGRAPHY

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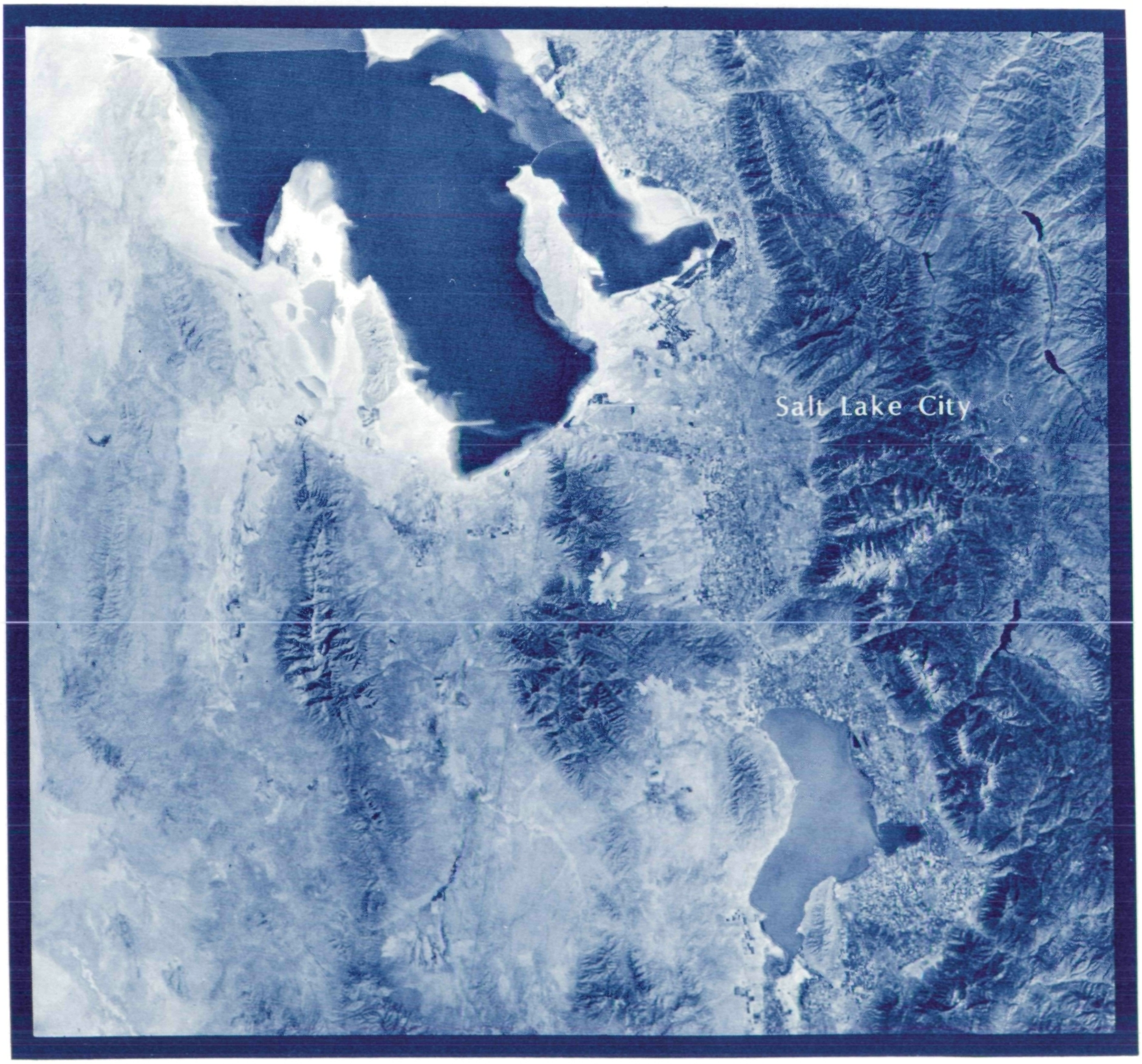

UNIVERSITY OF UTAH RESEARCH INSTITUTE

Salt Lake City

SEMIANNUAL REPORT

Identifying Environmental Features for Land Management Decisions

NASA Grant NAGW-95
April 1984

Prepared for

National Aeronautics and Space Administration

by

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INTRODUCTION

This report summarizes accomplishments of the Center for Remote Sensing and Cartography (CRSC) since August 1983. It has been an active period of presentations, publications, technical development, and moving.

New Location and Address

A temporary relocation in January 1984, and a more permanent move in March 1984, have resulted in the new address and telephone number indicated on the title page. The location is still within the Research Park adjoining the University of Utah campus. Administratively, CRSC remains a part of the University of Utah Research Institute.

The telephone number 801-524-3456 is both FTS and commercial, allowing us to call long distance anywhere in the USA at no cost. It is also the same exchange as federal government offices in Salt Lake City, facilitating more direct communication.

Personnel

Our still small staff is, in the aggregate, at its strongest level in CRSC history. The members are:

Merrill K. Ridd, Director (geomorphology, computer cartography, GIS)

John A. Merola, Manager (quantitative techniques, computer applications)

Kevin P. Price, Project Leader (range ecology, soils)

Douglas J. Wheeler, Project Leader (geography, geographic information systems)

Gordon E. Douglass, Systems Specialist (physical geography, computer applications)

Stephen Brower, Technician (Enviropod coordinator)

Kirk Fields, Technician (draftsman)

Saundra Buckley, Secretary (organizer, troubleshooter)

Presentations, Publications, and Workshops

Since August 1983, CRSC staff members have delivered seven papers at remote sensing conventions and/or conference sessions and organized /chaired two special sessions. (See Appendix A.) Most of the papers were published as part of the proceedings. Abstracts have been submitted for the 18th International ERIM Symposium in Paris, October 1-4, 1984; the 1984 World Conference on Remote Sensing at Bayreuth, Germany, October 8-10, 1984; and a Utah Hazards Conference in June 1984.

In March 1984, Ridd and Merola were invited to a special two-day workshop on arid/semiarid land applications of remote sensing at Reno, Nevada. The group included range scientists, geologists, geographers, hydrologists, and soil scientists. The level of technical interaction was deeper than at traditional conferences.

The 30 participants agreed that the interaction should continue as an "Arid Lands Remote Sensing Working Group." Merrill Ridd was "drafted" as a member of the ad hoc committee to establish the continuity and format.

Ridd has also been appointed to the Editorial Review Committee of the Professional Geographer for remote sensing articles. He continues as a member of the Publications Committee of the Remote Sensing Speciality Group of the Association of American Geographers, and has been appointed to the Visiting Scientists Program of the Association of American Geographers and Gamma Theta Upsilon.

CRSC FOCUS

The Center is accumulating a fair amount of experience in arid/semiarid environment research. Several new projects have begun in this area, and a major proposal on desertification research has been submitted to the National Science Foundation (NSF). Institutional ties with those engaged in arid land research are increasing at the Center.

However, we do not intend to relinquish progress made in alpine forestry environments and in urban-fringe analysis. Actually, the common thread tying all three together is a set of multivariate statistical and image processing techniques.

In simplest terms, it may be said our focus is becoming directed along three interrelated fronts:

1. Arid/semiarid environmental analysis, with particular emphasis on desertification. The thrust here is on the multistage/multiscale problem of sifting out field-level "indicators" of land-soil-biota degradation, staging up to the low aircraft reconnaissance level, to Landsat TM and MSS, and even AVHRR levels. An essential link in this hierarchy is the integrating nature of geomorphic "process-form" terrain units, which functionally incorporates the natural systems of substrate, soil, biota, climate/weather, and surface/subsurface water.

2. Spatial/spectral contextual analysis, with an emphasis on multivariate statistical techniques. These tools are applicable at the desert land classification level, the urban fringe change modeling level, and at the alpine forest succession modeling level. This set of procedures is schematically outlined in Figure 1. Although there are many routines, from ELAS and from CRSC's own innovations, that are not indicated in the illustration, the basic stream of procedures is shown.

3. Geographic information systems, with emphasis on the interface with remote sensing. Many CRSC projects incorporate digital ancillary data to stratify spectral data and improve the classification. Further, many of the projects call for "layered" information as discrete data sets, and in some cases, a geo-base data system is the objective of the research.

GLOBAL HABITABILITY

The spirit of Land-Related Global Habitability Sciences Issues statement (NASA Technical Memorandum 85841) is well met with CRSC's thrust. We are very comfortable with both major objectives and stated goals of the Global Habitability program. The unique contributions attainable for the first time with satellite and aircraft imaging are well

CRSC SEMISUPERVISED CLASSIFICATION PROCEDURE (——)

and IMAGE DIFFERENCING PROCEDURE (– – –)

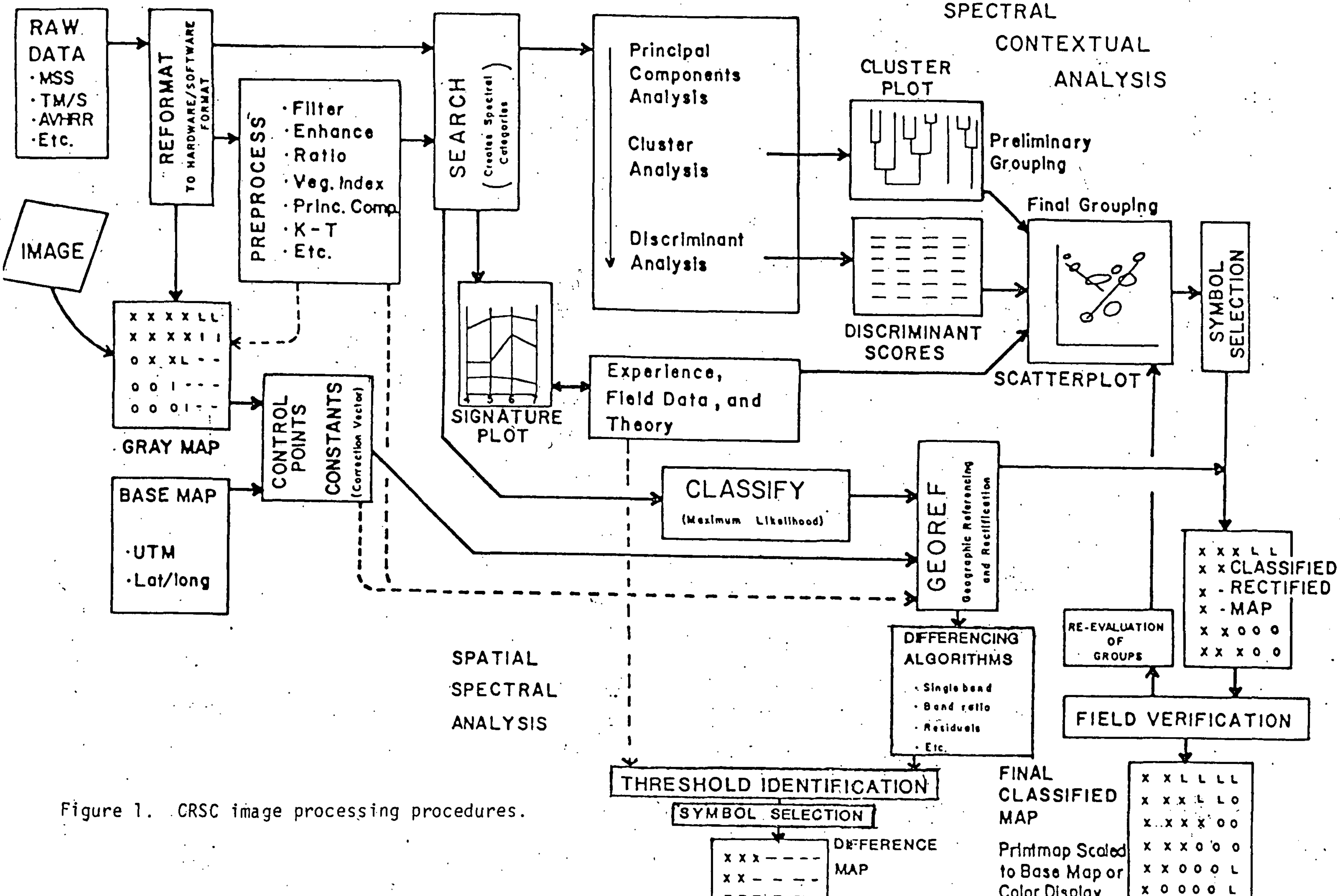

Figure 1. CRSC image processing procedures.

outlined and articulated in the document, although specific technical innovations are left to the researchers.

CRSC's fit within the five science elements is principally in the Land Surface Inventory, Monitoring, and Modeling arena. There are, however, significant cross-ties with the Biological Productivity and the Global Hydrologic realms. Surely, all remote sensing groups feel a kinship with the multistage scaling concepts shown in Figure 11, p.II.4-8. For our part, all three focus areas for CRSC--arid lands/desertification, spatial/spectral contextual analysis, and GIS analysis--are inextricably tied to this hierarchical spatial sampling concept.

We agree with the statement that, "Indeed, satellite remote sensors offer the potential, essentially for the first time, for the generation of globally consistent input data sets from which the absolute accuracy of derived cartographic products for very large areas can be authenticated by appropriate statistical sampling procedures." However, the word "potential" looms very large. For desertification at least, there has been so little research to support the common assertion since the Nairobi conference in 1977 that with the "new science" of remote sensing, we now have the tools to assess and monitor the conditions and progress of desertification over the vast regions of the world. Even to assess and map the current condition is an awesome task, not to mention the monitoring of change with any confidence.

The research ahead is staggering. Yet, the Working Group has done a laudable job of laying out the elements of the task.

Research projects at CRSC, especially the new ones, fit nicely into a number of the research areas and tasks listed. In the following highlights of projects, reference is made to "Tasks and Research Areas" under the

heading of "Land Surface Inventory, Monitoring, and Modeling." The six Research Areas are:

1. Global Land Surface Inventory and Monitoring (12 tasks)
2. Modeling (emphasis on temporal) (9 tasks)
3. Classification Systems (5 tasks)
4. Sampling (emphasis on spatial) (7 tasks)
5. Algorithm Development (4 tasks)
6. Geo-based Information Systems (4 tasks)

PROJECTS COMPLETED

Since August 1983, three research projects have been completed.

Riparian Habitat on the Humboldt River Floodplain.

This project, led by Kevin Price, established a significant step toward understanding river dynamics with respect to changing geomorphic, hydrologic, and biotic conditions. The principal remote sensing tool was the EPA's Enviropod photography flown by CRSC.Through the effects of man's manipulation of the stream channel and near-stream environments, it was shown that large tracts of floodplain above Elko have been seriously de-watered, and other areas flooded with debris.

A historical photo analysis of photos from 1950 to 1983 demonstrated a dramatic reduction of the meander ratio and xerification (desertification) of the floodplain through human intervention. The work fits Task 3 of Research Area (RA)#1, GH Land Surface Modeling. The quality of research

results has led to a second research project contract on a Humboldt tributary drainage, funded by the Nevada Department of Wildlife Resources.

Salt Lake County Urban Expansion Detection

Although this research project is not completed, some important findings have emerged. Most important is that classification algorithms and change detection algorithms that have been reported effective elsewhere have not worked in Salt Lake County. Small and irregular plots of land have proven inaccessible to MSS data. Classifications based on principal components Analysis (PCA) of raw data, of SEARCH statistics, and of filtered data, ratioed data, and vegetation indeces have been disappointingly weak. Change detection routines based on band 5 showed poor results, unlike findings in other urban areas where band 5 was reported to be quite effective and the best of several algorithms. Differencing band 7, band 7/5 ratios, band 7-5/band 7+5 vegetation indeces, and Kauth-Thomas transformations were employed. All were ineffective. Finding a threshold of change on the histogram is impossible without raising errors of either omission of commission to unacceptable levels.

The basic reasons seem to be the small field sizes and irregular shapes, and the fact that in the two-year time span between the two dates, only small amounts of land were converted from farm to urban use. This was a period of depressed construction.

However, from the MSS statistics generated, Figure 2 was constructed from PCA, and a temporal model of change proposed as Figure 3. Three new directions are coming from the research:

1. Extend the time span to five or more years so that larger tracts of land conversion will be involved.

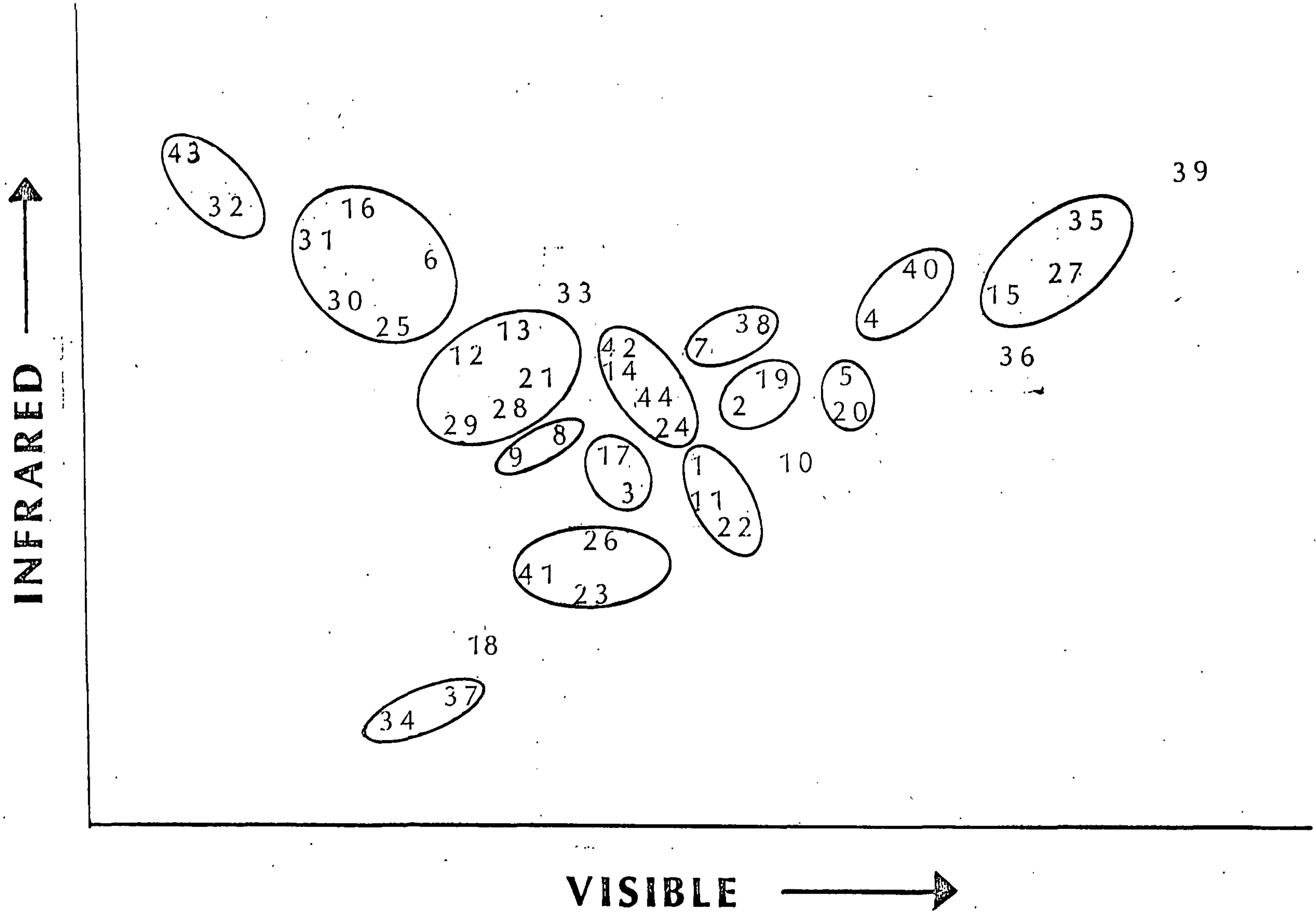

Figure 2. Canonical plot of Salt Lake County MSS data.

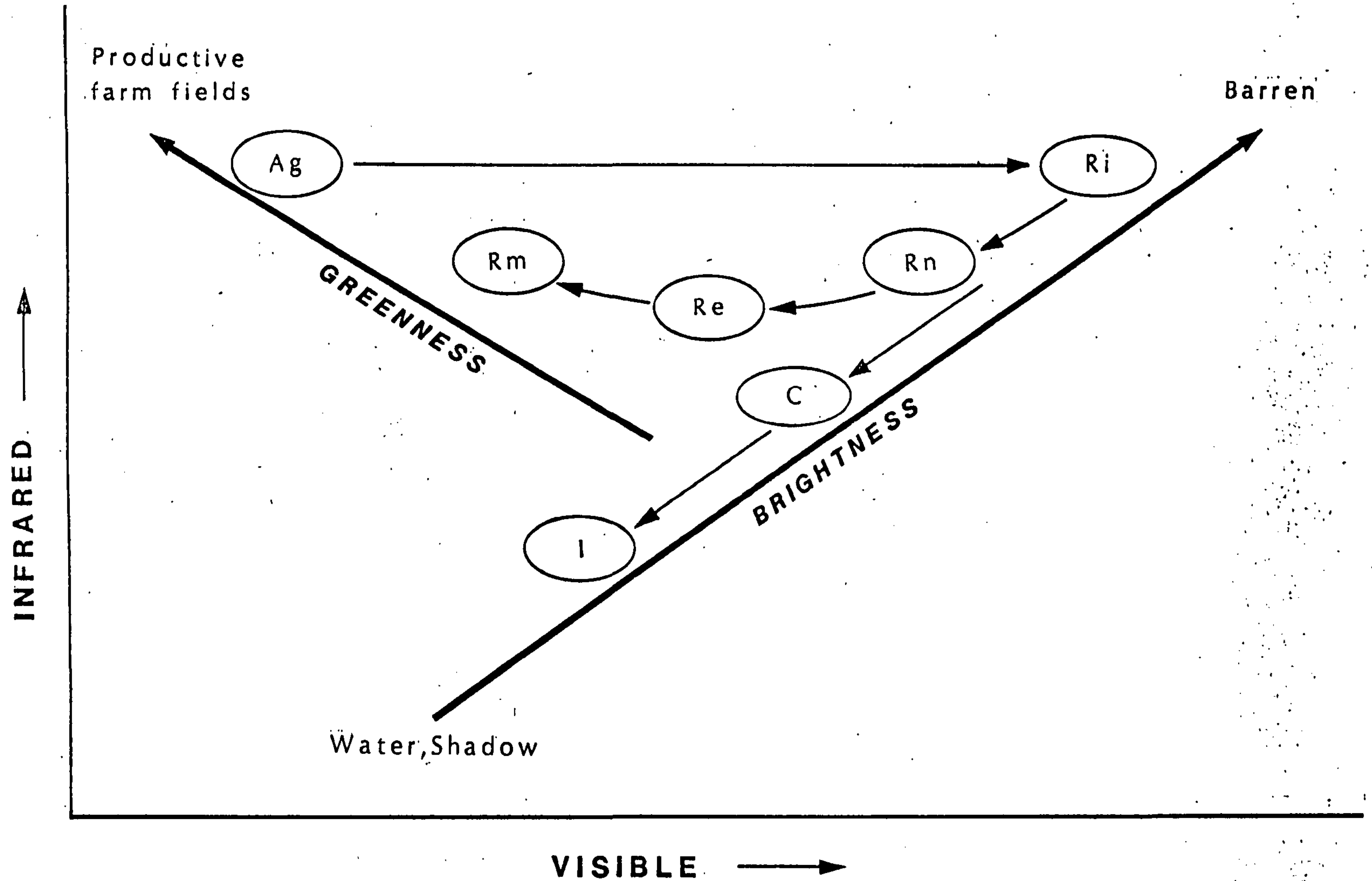

Figure 3. Temporal model of agricultural to urban land conversion. Ri = residential incipient (cleared for housing), Rn = residential new, Re = residential established, Rm = residential mature, C = commercial, and I = industrial.

2. Employ TMS data. This has begun, and, of course, shows much more detail. The objective now is to use filtering algorithms to reduce the "noise" level in the TMS data. This is in line with the spatial/spectral contextual analysis focus mentioned earlier. We have been discussing this with NASA/ERL researchers.

3. Using detailed land use maps completed for 1982 as the base line, establish a periodic time sequence update on urban change. Stratify the county by geomorphic types to reduce spectral confusion. Digitize incremental additions of public parks/schools/ etc., that would be confused spectrally with farmland. Employ the temporal model shown in Figure 3. This research is directly in line with Task 5, RA#3.

<u>Salinization/Desertification Detection in the Delta Area</u>

A master's degree has just been completed at the Center by Julie Kerr, a Bureau of Land Management employee. The objective was (a) to determine which in-situ measures best indicate soil salinity, (b) which spectral variables are most sensitive to those field measures, and (c) which multivariate routines best access those spectral variables. This procedure is directly in line with Task 1, RA#1.

Appendix B is an abstract of the results, pepared for the ERIM Paris symposium. The results were very promising. From all the statistical techniques used, the Kauth-Thomas brightness and greenness coefficients consistently showed the highest correlations, up to a .9 significance level. Total cover minus cryptogams and percent bare soil were the best field surrogates to salinity.

PROJECTS UNDERWAY OR BEGINNING

Comparative Condition of Rangeland in Rush Valley

This research for the Utah Department of Agriculture is designed to classify desert rangeland into comparative levels of productivity from MSS data. Kevin Price is project leader. A form of area frame sampling is employed to select field sites for ecological measures. Low level Enviropod panoramic photography is used as part of the sampling strategy consistent with Tasks 1 and 6, RA#4.

A second phase of the research will be an attempt at "absolute" rating of productivity, based on a benchmark "relict" area off limits to grazing, a military reserve since the 1940s. This base line reference is in keeping with Task 3, RA#1, and Task 2, RA#3.

Modeling a GIS/Remote Sensing Data Base, Cache County

CRSC's director has been appointed to the Governor's Science and Technology Committee, Panel on Scientific Inputs to Land Use Planning. The panel, in defining its charter, has opted to build a model operating GIS. Cache County in northern Utah was selected by CRSC and the State Department of Agriculture, the funding agency. The objective is to establish a working model of GIS in action. CRSC's Doug Wheeler is project leader, using this as his Ph.D. dissertation research.

The objectives of the project are to identify information needs and to build and integrate a data base from multiple sources (Task 1, RA#5) that will serve as a base line for decision making and for change analysis. Another goal is to mesh the results of another university's Land Evaluation

and Site Assessment (LESA) into the data structure. The final goal is to ensure the final data and analytical results will enter into the state's budding GIS system.

The new state system is based on a PRIME computer with ARC/INFO software. It is compatible with CRSC's PRIME/ELAS configuration. These goals are consistent with Tasks 2 and 3, RA#5 and Tasks 1 and 2, RA#6 relative to structure, capacity, and positional accuracy of the several data planes. These will all be part of the evaluation.

Universal Soil Loss Equation Applied to Pinyon-Juniper

This research project, carried out with cooperation of the U.S. Soil Conservation Service, is designed to delineate variations within a given ecotype (pinyon-juniper woodland), specifically variations in cover/condition that depict degrees of soil erosion. (See Task 9, RA#1 and Tasks 1, 2, and 3, RA#3.)

The objective is to automate the USLE model insofar as possible. Three of the factors in the equation will be digitized from conventional maps. Slope degree and length will be derived from Digital Elevation Model (DEM) tapes, while the final factor, cover, will be derived from Landsat MSS data. (See Task 4, RA#3.)

Kevin Price is project leader, using this as his Ph.D. dissertation research. If the model can be successfully employed in an automated mode, thousands of hectares of pinyon-juniper woodland in the West may be stratified and targeted for reclamation before erosion strips away the opportunity.

Relating Landsat MSS to Ground Radiometry near Battle Mountain

This joint project with the US Army Engineer Topographic Laboratories is on a desert landscape near Battle Mountain, Nevada. The basic objective will be to seek degrees of correlation between ground level radiometer data with Landsat digital data, especially with respect to geomorphic features. (See Tasks 1 and 9, RA#1 and Task 1, RA#4.)

The project will involve contract stretching and other computer enhancement techniques to bring out geomorphic/soil/vegetation variability.

Riparian Habitat Mapping on Mary's River, Nevada

This is a follow-on project from the Humboldt floodplain research. The procedures will be essentially the same, using low level Enviropod photography to assess river morphology and dynamics. River course dynamics will be related to upstream geomorphic condition.

Enviropod

The EPA Enviropod panoramic camera system made available to the State of Utah through CRSC last year may be made available again. The agreement ended in March, but is under review for renewal. The pod was a blessing and a curse. We did obtain excellent low-level photography over several CRSC project areas in Utah and Nevada, increasing the speed and accuracy of our work. On the other hand, the number of natural hazard emergencies that innundated Utah last spring and summer kept CRSC over-obligated in off-line activated at times. However, it has helped establish credibility and professionalism as a versatile remote sensing center.

RESEARCH PROJECT DEVELOPMENT

CRSC has made a considerable effort to develop research projects with strong institutional ties. To some extent, this has materialized with the states of Utah and Nevada, and with some federal agencies, including the Department of Army. Our work in Mexico for several years established a sound working relationship with the Mexican government and a major university. Ties to NASA centers have been strong in a communications mode and in shared technical development, but need to be strengthened in direct disciplinary research effort. Some steps have been taken.

Desertification Proposal to NSF

A major proposal has been submitted to the National Science Foundation (NSF) for a three-year study on desertification. The project would be based in Utah and Mexico. The objective is basically a spatial/temporal sampling strategy based on the area frame principle from satellite, to low aircraft (Enviropod), to field sampling. It is built on previous experience working with CONAZA (Comision Nacional de las Zonas Aridas), the Universidad Autonoma San Luis Potosi, and the Instituto Investigaciones Deserticas.

The project would involve calibration in Utah at well-documented sites at the Desert Experimental Range, a Biosphere Reserve of the MAB program, and testing/verification in Mexico. The project would involve spatial and temporal sampling and stratification techniques from regional to local to site specific measures. The project strikes at the heart of Global Habitability objectives.

Man and Biosphere (MAB)/NASA/US Forest Service

On March 21, 1984, Dale Quattrochi of NASA/ERL; Rowan Rountree of the US Forest Service Urban Forestry program in Syracuse, New York; Steven Henson of the Utah Division of Lands and Forestry met at CRSC to begin a working discussion on urban ecosystems." The objective was to explore mutual research interests. Quattrochi, an urban climatologist, had talked with Roger Soles, Executive Director of MAB, and Paul Baker, Chairman of the US MAB Committee, and had received encouragement about reestablishing the defunct Urban Ecosystems Directorate, with a new focus. Rountree is already underway with an urban forestry project in Salt Lake County, in conjunction with the state. The group came to Salt Lake to talk about CRSC's remote sensing work in the county. The mutuality of research interests was gratifying. One of the potential strengths of the relationship is the mutual familiarity with and use of ELAS software.

A schematic working relationship was sketched out. It was agreed that Quattrochi would draft a mini-proposal for review. Quattrochi and Ridd will meet in Washington to go over the draft. ERL is exploring the possibility of sending Quattrochi to Salt Lake City to work at the CRSC laboratory and pursue a Ph.D. degree while at the research site. Whatever the specific outcome, the potential for research interaction is high.

Working Ties with NASA Centers

Preliminary discussions are underway between CRSC and three of NASA's centers: Goddard Space Flight Center, Earth Resources Laboratory, and Johnson Space Center. At GSFC, we have talked briefly with Vince Salomonson about possible interactions with specialists in soil moisture (Schmugge), arid land hydrology (Salomonson), and software (Williams).

At ERL, we have many ties especially through software development and documentation, where Merola and Ridd helped establish the "charter" ELAS users group, and Merola now heads up the documentation committee. We have worked with many ERL specialists over the years. For a science-connection, we are particularly oriented to Musick and Joyce re desertification, and Quattrochi for urban ecosystems.

At JSC, we have been interacting with Robert Mohler relative to geobotany studies as an aid to arid land vegetation mapping, possibly incorporating Shuttle imagery and/or AVHRR. The mutual interest in arid lands is strong.

These discussions have only begun, based on long-standing personal relationships. A systematic assessment of these and other possible mutual interests will be pursued this summer.

Contact has also been established directly with Roger Soles and Bill Gregg of the MAB program. Some possible research areas will be explored under the directorate of Arid and Semiarid Lands, Urban Ecosystems, and Biosphere Reserves.

TECHNICAL DEVELOPMENT

Significant technical advancements have been made in the past six months.

1. John Merola remains active as chairman of the ELAS User's Group Committee on Documentation. This vital activity is helping to tie users closer together and to share important technical capabilities.

2. CRSC has been documenting the SEARCH routine rather extensively. SEARCH is one of the fundamental routines in all of ELAS, and is poorly understood by many users. The documentation will explain, step-by-step, what each algorithm is doing.

3. An in-depth, detailed ELAS training manual is being prepared at CRSC to be shared across the user community. The manual is sorely needed whenever a new person is brought in. So much "teacher" time is needed because of the inadequate present record. The new manual will be especially helpful for those who do not have a display device.

4. Improvements in the print class (PCLS) routine have been made. The routine is used just to print classified data for classes 0 to 99. The new improvements permit handling gray level maps to 255 levels, and can specify start and stop lines.

5. A program called PRETTY has been acquired from the College of Science at the University of Utah. The program remembers lines, engages do-loops, and makes the code easier to read.

6. Progress continues on a variety of multivariate statistical programs that serve nearly every project.

7. The ELAS segment digitizing program (SGDZ) has been installed and debugged. It has been converted for use on a Tektronics Plot 10 terminal control system. This will be used liberally in

several projects just underway.

8. A class in computer mapping, and a graduate seminar/workshop in GIS/remote sensing have strengthened our skills as a group. These, too, will aid in new research projects.

Presentations and Publications

The following titles were presented by CRSC staff members since August 1983:

ASP/ACSM Convention, Salt Lake City, September 19-23

John A. Merola, "Detection of Aspen/Conifer Mixes from Multitemporal Landsat Digital Data," coauthored by R. A. Jaynes, CRSC, and R. O. Harniss, U.S. Forest Service.

Merrill K. Ridd, "Detecting Agricultural to Urban Land Use Change from Multitemporal MSS Digital Data," coauthored by J. A. Merola and R. A. Jaynes, CRSC.

Kevin P. Price, "Parker Mountain Range Resource Inventory: Applications of CIR Photography Ancillary Data, and Landsat Digital Data," authored by R. A. Jaynes, CRSC.

Clark Fetzer, "Remote Sensing Evidence and Experts in the Courtroom" authored by R. A. Jaynes, CRSC.

Merrill K. Ridd chaired session on "Remote Sensing of Natural Resources III."

Assoc. of Am. Geographers Meeting, Denver, October 14-16

Merrill K. Ridd organized and chaired a session on remote sensing/GIS interfacing.

John A. Merola, "Digital Contextual Analysis in Aspen/Conifer Detection."

ASP/ACSM Convention, Washington, D.C., March 11-16

John A. Merola, "Contectual Analysis of Landsat Spectral Signatures."

Merrill K. Ridd, "Evaluating Landsat MSS Digital Data for Change Detection at the Urban Fringe," coauthored by J. A. Merola.

Arid Land Remote Sensing Workshop, Reno, March 23-24

John A. Merola, "Contextual Analysis of Landsat Spectral Signatures."

Merrill K. Ridd, "Integration of MSS and Ancillary Digital Data: Parker Mountain Range Study."

18th International Symposium on Remote Sensing of Environment - ERIM, October 1-5, 1984, Paris, France

ABSTRACT

Multivariate Strategies in Detecting Soil Salinity/Desertification from Landsat MSS

by

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A growing global problem is the advancement of desertification, resulting in serious economic and environmental stress. One of the often-stated indicators of desertification is salinization of the soil, and its impact on vegetation.

This paper reports on a detailed statistical/field strategy associating field data and Landsat MSS data. The field data include soil salinity, texture, and erosion factors; vegetation total cover and various life form densities; and geomorphic unit types. The satellite data include brightness values of various bands, albedo values, band ratios, vegetation indices (band 7 + band 5/band 7-band 5), and Kauth-Thomas (K-T) brightness and greenness indices. The number of variables and derivatives combine to a total of 38. The study area is an open rangeland in the Great Basin portion of western Utah.

The critical questions are:

1. Which field variables, indicative of degrees of salinization, are meaningful to obtain?

2. Which satellite data parameters are sensitive to, and diagnostic of, those variables?

3. Which statistical operators and derivatives can best establish the sensitivity of satellite data parameters to the critical field variables?

Four statistical approaches were used: (1) correlation analysis, (2) principal components analysis, (3) regression analysis, and (4) analysis of variance. Using Pearson's product moment correlation coefficient on all interval and ratio-scaled variables, pairs of variables with positive or negative correlation were identified. The strongest correlations relate K-T brightness and K-T greenness to total cover, bare ground, and salinity (log). Vegetation indices and band ratio are poorly correlated with any significant field variables. Principal component analysis further substantiates the potential of K-T brightness and K-T greenness indices to be sensitive to salinity indicators, with loadings in excess of .80 relative to total cover, bare ground, and salinity.

Three regression analysis procedures established the most highly correlated "other" field variables with salinity, and the most highly correlated spectral variables with salinity. K-T brightness and K-T greenness, band 7, and band 5 showed close correlations with bare ground, total cover, and shrub/forb composition. These derivatives also had the highest F-ratios and lowest F-probability values. Albedo values showed moderate correlation, while band 7/5 ratio and the vegetation index are extremely low.

Using the Daubenmire technique for categorizing cover classes, analysis of variance was used to relate albedo, K-T brightness, K-T greenness, vegetation index, and salinity to seven vegetation cover/ground condition measures (total cover, total cover minus cryptogams, shrub/forb cover, bare ground, presence of soil polygons, size of soil polygons, and percent slope). Again the K-T indices were consistently superior and showed very high F scores. Albedo showed some promise, but the vegetation index did not prove useful.

In conclusion, of the many field variables obtained, those most closely associated with salinity are total cover, total cover minus cryptogams, and bare ground. The spectral derivatives most sensitive to, and diagnostic of, these cover conditions are K-T brightness and K-T greenness. This high-level relationship held consistently through all analyses, including analysis of variance, where significance was established at the .9 level. On the basis of this study, it appears that Landsat MSS data is an effective tool for the delineation of degrees of salinity in rangelands of the Great Basin. By using K-T indices of MSS data, it appears that significant statements may be made of total cover (Daubenmire classes) and salinity levels.

Table 1. CRSC Projects Supported in Whole or Part by NASA Grants NSG-7226 and NAGW-95

Project Short Title	CRSC Report	Agency/ies	Agency Support	Completed	Project Impact
PROJECTS COMPLETED					
North Ogden Hazards to Urban Development	78-1	Weber County, No. Ogden City, Pleasant View	Limited in Kind	May 1978	Adopted for Sensitive Area Overlay Zone Ordinance.
Irrigation Detection by Satellite, Iron Co.	79-1	Utah Div. of Water Rights	Limited in Kind	April 1978	Proven effective. Led to ground water study.
Price River Basin Rangeland Response to Summer Rain	79-2	U.S. Bureau of Land Management	Limited in Kind	May 1979	Proven effective but demands real-time data for application.
Korean Land Use II	79-3	Republic of Korea	$102,000	Aug. 1979	NASA funding helped develop software; technical development.
Snowpack/Runoff Correlation	Exper-imental	Utah Div. of Water Resources Soil Cons. Serv.	Limited	--	High correlations shown. Tabled until near real-time data is available.
Guayule Inventory I: Contrast Enhancement	80-1	Mexican Government	$90,000	Jan. 1980	NASA funding helped perfect computer enhancement.
Uinta Basin Wetland/Land Use	80-2	Utah Div. of Water Resources Soil Cons. Serv.	$10,000 $25,000	Dec. 1980	Wetland management, water allocation and management, agriculture resource planning.
Snow Cover/Mule Deer	80-3	Utah Div. of Wildlife Res.	Limited in Kind	July 1980	Landsat utility, tabled pending agency studies.
MX Draft EIS Review	81-1	Utah Governor's Office	ca. $2,000	April 1981	Used by Governor for MX policy and comment.
Guayule Inventory II: Statistical Classification Routines	81-2	Mexican Government	$100,000	Feb. 1981	NASA funding helped develop classification routines.
Farmington Bay Shoreline	81-3	Utah Div. of Wildlife Res. Great Salt Board	In Kind Minimal	April 1981	Deterred proposed project which would have damaged waterfowl habitat.
Irrigation Detection, Iron County II	81-4	Utah Div. of Water Rights	Minimal	May 1981	Proven effective; led to Bear River Study; leading to prosecution.
Davis County Foothill Development	81-5	Davis County Planning Comm. Four Corners Regional Comm. EPA 208 Weber-Davis Several State Agencies Seven municipalities	In Kind $63,000 $18,000 In Kind In Kind	May 1981	Being reviewed for adoption as the guideline for urban development control.

CRSC Projects Supported in Whole or Part by NASA Grants NSG-7226 and NAGW-95.

Project Short Title	CRSC Report	Agency/ies	Agency Support	Completed/ Anticipated Completion	Project Impact
Sevier River Basin Wetland; Land Use	81-6	Soil Conservation Service	$23,000	Oct. 1981	Basic information for wetland mgt. and water allocation.
Farmington Bay Wildlife Habitat	82-1	Utah Division Wildlife Resources	In Kind	Mar. 1982	Likely to influence diking, revegetation, wetland permits.
Bear River Range Aspen Habitat	82-2	U.S. Forest Service, NSF	$11,000	Mar. 1982	Statistical signature refinement. Lead to riparian study.
Bear River Basin Irrigation Land Inventory	82-3	Bear River Commission	$ 9,000	Apr. 1982	Will be basis for water allocation between states.
Aspen/Aspen-Conifer Detection	82-4	Intermountain Forest & Range Experiment Station	$ 7,499	June 1982	Improve inventory techniques and habitat analysis.
San Luis Potosi Rangeland Inventory	82-5	Mexican Government	$52,000	Feb. 1982	NASA funding helped develop technical expertise for digital analysis.
Parker Mountain Rangeland	82-6	Utah Division of State Lands and Forestry	$ 4,541	Dec. 1982	Basic information and recommendations for revegetation and range management.
Multitemporal Aspen/Conifer Detection	83-1	Intermountain Forest & Range Experiment Station	In Kind	Mar. 1983	Refinement of techniques for forest inventories.
Land Use Inventory of Salt Lake Co.	83-2	Utah Division of Water Resources	$17,248	Apr. 1983	Data for hydrologic modeling and change detection.
Wasatch-Cache Riparian Vegetation	83-	U.S. Forest Service	$ 3,500	Sep. 1983	Basic information for wetland and wildlife management.
Humboldt River Riparian Habitat	83-3	Nevada Dept. of Wildlife	$ 8,344	Oct. 1983	Information base for developing wildlife habitat policies and technique development for habitat monitoring.
Enviropod Handbook	84-1	FEMA	$ 1,200	Apr. 1984	
EPA - Enviropod	84-2	U.S. EPA and various state agencies	In Kind	Apr. 1984	Planning and acquisition of Enviropod photography, and evaluation of results.
Middle Sevier	84-3	Utah Division of Water Resources	$25,000	June 1984	Basic information for wetland management and water allocation.
Salinity/ Desertification Detection	84-	Thesis	In Kind	April 1984	